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Decision making based on analysis of benefit versus costs of preventive retrofit versus costs of repair after earthquake hazards

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In this presentation interventions on seismically vulnerable early reinforced concrete skeleton buildings, from the interwar time, at different performance levels, from avoiding collapse up to assuring immediate post-earthquake functionality are considered. Between these two poles there are degrees of damage depending on the performance aim set. The costs of the retrofit and post-earthquake repair differ depending on the targeted performance. Not only an earthquake has impact on a heritage building, but also the retrofit measure, for example on its appearance or its functional layout. This way criteria of the structural engineer, the investor, the architect/conservator/urban planner and the owner/inhabitants from the neighbourhood are considered for taking a benefit-cost decision. Benefit-cost analysis based decision is an element in a risk management process. A solution must be found on how much change to accept for retrofit and how much repairable damage to take into account. There are two impact studies. Numerical simulation was run for the building typology considered for successive earthquakes, selected in a deterministic way (1977, 1986 and two for 1991 from Vrancea, Romania and respectively 1978 Thessaloniki, Greece), considering also the case when retrofit is done between two earthquakes. The typology of buildings itself was studied not only for Greece and Romania, but for numerous European countries, including Italy. The typology was compared to earlier reinforced concrete buildings, with Hennebique system, in order to see to which amount these can belong to structural heritage and to shape the criteria of the architect/conservator. Based on the typology study two model buildings were designed, and for one of these different retrofit measures (side walls, structural walls, steel braces, steel jacketing) were considered, while for the other one of these retrofit techniques (diagonal braces, which permits adding also active measures such as energy dissipaters) to different amount and location in the building was considered. Device computations, a civil engineering method for building economics (and which was, before statistics existed, also the method for computing the costs of general upgrade of buildings), were done for the retrofit and for the repair measures, being able to be applied for different countries, also ones where there is no database on existing projects in seismic retrofit. The building elements for which the device computations were done are named "retrofit elements" and they can be new elements, modified elements or replaced elements of the initial building. The addition of the devices is simple, as the row in project management was, but, for the sake of comparison, also complex project management computed in other works was compared for innovative measures such as FRP (with glass and fibre). The theoretical costs for model measures were compared to the way costs of real retrofit for this building type (with reinforced concrete jacketing and FRP) are computed in Greece. The theoretical proposed measures were generally compared to those applied in practice, in Romania and Italy as well. A further study will include these, as in Italy diagonal braces with dissipation had been used. The typology of braces is relevant also for the local seismic culture, maybe outgoing for another type of skeleton structures the distribution of which has been studied: the timber skeleton. A subtype of Romanian reinforced concrete skeleton buildings includes diagonal braces. In order to assess the costs of rebuilding or general upgrade without retrofit, architecture methods for building economics are considered based on floor surface. Diagrams have been built to see how the total costs vary as addition between the preventive retrofit and the post-earthquake repair, and tables to compare to the costs of rebuilding, outgoing from a the model of addition of day-lighting in atria of buildings. The moment when a repair measure has to be applied, function of the recurrence period of earthquakes, is similar to the depth of the atria. Depending on how strong the expected earthquake is, a more extensive retrofit is required in order to decrease repair costs. A further study would allow converting the device computations in floor surface costs, to be able not only to implement in an ICT environment by means of ontology and BIM, but also to convert to urban scale. For the latter studies of probabilistic application of structural mechanics models instead of observation based statistics can be considered. But first the socio-economic models of construction management games will be considered, both computer games and board hard-copy games, starting with SimCity which initially included the San Francisco 1906 earthquake, in order to see how the resources needed can be modeled. All criteria build the taxonomy of decision. Among them different ways to make the cost-benefit analysis exist, from weighted tree to pair-wise comparison. The taxonomy was modeled as a decision tree, which builds the basis for an ontology.